Time and Size at Release Experiment: Four Releases of Three Size Categories of Juvenile Chinook Salmon From the Quinsam Hatchery in the Spring of 1983

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TIME AND SIZE AT RELEASE EXPERIMENT: FOUR RELEASES OF THREE SIZE CATEGORIES OF JUVENILE CHINOOK SALMON FROM THE QUINSAM HATCHERY IN THE SPRING OF 1983

by

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ABSTRACT

Bilton, H. T., R. B. Morley, A. S. Coburn, and D. Brouwer. 1984. Time and size at release experiment: four releases of three size categories of juvenile chinook salmon from the Quinsam Hatchery in the spring of 1983. Can. Data Rep. Fish. Aquat. Sci. No. 463: 23 p.

This report provides, in readily accessible form, background information required to assess the results of an experiment in progress at the Quinsam River production hatchery, Campbell River, B. C. The experiment is designed to measure the effects of time and size at release of juvenile chinook salmon (Oncorhynchus tshawytscha) on their subsequent survival, growth, distribution, and age at maturity. In the spring of 1983, four releases (May 5, May 26, June 16, and July 7) of juvenile chinook salmon, each comprised of three size groups, were released from the Quinsam River hatchery, representing a combined total of 359,514 marked and tagged fish. Information from samples collected just prior to release on lengths, weights, sex composition, health, body composition, and ability of released fish to adapt to sea water is given.

Key words: Quinsam, chinook, release size, release time.

RÉSUMÉ

Bilton, H. T., R. B. Morley, A. S. Coburn, and D. Brouwer. 1984. Time and size at release experiment: four releases of three size categories of juvenile chinook salmon from the Quinsam Hatchery in the spring of 1983. Can. Data Rep. Fish. Aquat. Sci. No. 463: 23 p.

Le présent rapport fournit, sous une forme facilement accessible, des données fondamentales requises pour l'évaluation des résultats d'une expérience en cours à la pisciculture de la rivière Quinsam, à Campbell River (C.-B.). Cette expérience vise à quantifier l'incidence du moment de la mise en liberté et de la taille des saumons quinnats (Oncorhynchus tshawytscha) juvéniles relâchés, sur la survie, la croissance, la répartition et l'âge à maturité. Au printemps 1983, quatre lâchers de juvéniles (5 mai, 26 mai, 16 juin et 7 juillet), chacun composé de trois classes de longueur, ont été effectués à la piscifacture de la rivière Quinsam. Au total, 359 514 poissons marqués et étiquetés ont été mis en liberté. Le rapport comprend aussi des données sur la longueur, le poids, le sexe, l'état de santé, l'analyse immédiate et la capacité à s'acclimater à l'eau de mer, données recueillies d'échantillons prélevés avant le lâcher.

Mots-clés: Quinsam, saumon quinnat, taille au lâcher, moment du lâcher.

INTRODUCTION

The purpose of this report is to provide, in readily accessible form, background information required in a current experiment on the effects of time and size at release of juvenile Quinsam River chinook salmon (Oncorhynchus tshawytscha) on their subsequent survival, growth, distribution, and age at maturity. The report has been divided into five major sections: the first deals with the smolt releases; the second with disease; the third with sea-water challenge tests; the fourth with numbers of tagged juveniles recovered by the Coastal Habitat group in a study of the Campbell River estuary and adjacent waters; and the fifth with lipid, protein, and moisture content of fish released.

This is the second consecutive year of two planned series of releases, the releases made in 1982 are described in Bilton, et al. 1983.

SECTION I. SMOLT RELEASES

MATERIALS AND METHODS

a) Donor stock and rearing

A part of the production stock of 1982 brood Quinsam hatchery juvenile chinook were used for the experiment. Fish assigned to the experiment were reared separately from the production fish using normal hatchery water supply, in 2 Burrow's ponds, at production densities. Fish were fed Oregon moist pellets (OMP) according to hatchery feeding schedule.

b) Experimental design

The object of the experiment was to release three sizes of juvenile chinooks on each of four dates. Size groups were achieved by grading the population of fish in each pond into small, medium, and large length categories. Each size group was replicated three times. Thus, there were nine groups planned for each release, making a total of 36 groups for all four releases. The design was as shown below:

Release date and number of fish

Size Category	May 5	May 26	June 16	July 7
Small	10,000	10,000	10,000	10,000
	10,000	10,000	10,000	10,000
	10,000	10,000	10,000	10,000
Total	30,000	30,000	30,000	30,000

Size Category	May 5	May 26	June 16	July 7
Medium	10,000	10,000	10,000	10,000
	10,000	10,000	10,000	10,000
	10,000	10,000	10,000	10,000
Total	30,000	30,000	30,000	30,000
Large	10,000	10,000	10,000	10,000
	10,000	10,000	10,000	10,000
	10,000	10,000	10,000	10,000
Total	30,000	30,000	30,000	30,000
Grand total	90,000	90,000	90,000	90,000

c) Nose-tagging and marking

All fish were tagged and marked during the period April 19 to May 20, 1983. For the May 5 release, 93,656 fish were tagged from pond A and transferred into a second pond for release. For the May 26 release, the remaining fish in pond A were driven into one-half of the pond, screen dividers were put in place,and 92,977 fish tagged and transferred into the other half of the pond for release.

For the June 16 release, 92,208 fish were tagged from pond B and transferred into a second pond for release. For the July 7 release, the remaining fish in pond B were driven into one-half of the pond, screen dividers were put in place, and 93,079 fish tagged and transferred into the other half of the pond for release. A sample of 1,000 fish was taken just prior to the first tagging session for each pond. These were anesthetized, measured for length, and returned to the pond. Length-frequency curves derived from these data were used to determine the size categories for marking. Arbitrarily, it was decided that fish with lengths falling within the 5% tails of the curve would be rejected to remove out-riders and that the remaining 90% would be divided into three equal portions, classified as small, medium and large. Because of the rapid growth of the fish at this time of the year, the limits delineating each size category had to be moved upwards several millimeters every two to three days throughout all four tagging sessions (a session lasted 10-12 days).

Once size categories were determined, marking and tagging of the fish was initiated. Fish were first anestnetized and graded to size category. The adipose fin was then removed and the appropriate binary coded magnetic wire nose tag applied.

d) Release

Approximately 900 tagged fish were randomly removed from the release pond on the day of each release. These fish were killed and retained for subsequent examination for presence of a tag, tag code, length, weight, and

sex. A further 90 fish (30 small, 30 medium, and 30 large) were killed and frozen for subsequent proximate analysis by D. Higgs. Before each release, a sample of 100 fish were examined for disease. (G. Hoskins). In addition, samples of approximately 36 live fish (12 small, 12 medium, 12 large) were removed just prior to release and tested by C. Clarke for their ability to adapt to sea water as measured by blood sodium levels after 24 h exposure to sea water (Clarke and Blackburn 1977).

Each release of fish began in the late afternoon by removal of stop logs from the end of the pond leading directly to a channel to the river. Fish were released on May 5, May 26, June 16, and July 7, 1983.

RESULTS

a) Numbers tagged and size at release

The numbers of tagged fish released on each date are given by tag-code in Tables 1-4. Also given in Tables 1-4 are estimates (based on release samples) of mean lengths and weights of fish by sex in each of the groups. An estimated total of 365,920 marked fish were released, of which 359,514 were estimated to have a tag (based on incidence of marked fish without tags in the release samples). Estimated tag loss was: May 5 release - 1.96%, May 26 release - 1.67%, June 16 release - 1.12%, July 7 release - 2.38%.

b) Sex ratios

Sex ratios observed in the release samples were examined both for differences between various categories and for deviations from a 50:50 ratio. The actual numbers of males and females in each sample are given in Tables 1-4 with sample sizes ranging from 62 to 139 (average 97). The proportion of males in each sample was calculated and are given in Table 5.

In summary, tests of the sex ratios (see Appendix A for details) observed in release samples showed the following:

1. There were no significant differences in sex ratios between releases, sex ratio in all cases did not deviate significantly from 50:50.

2. There was a strong effect of size, with increasing size accompanied by a progressive increase in the proportion of males. This was highly evident in the first three releases and may have occurred in the fourth also.

3. Small category fish showed a significant predominance of females while large fish showed a significant predominance of males. The sex ratio of medium category fish did not deviate significantly from 50:50.

4. Differences in sex ratios between size categories were statistically significant only between small and large category fish.

5. The sex ratio of the population as a whole (all samples combined) was not significantly different from 50:50.

SECTION 2. DISEASE

This section was provided by the Diagnostic Services Section of the Pacific Biological Station and summarizes the methods and results of disease examination of fish from each of the four releases.

The following samples of chinook juveniles were randomly selected from the release ponds on dates indicated.

Case No.	Release date	Collection date	Number examined
83-163	May 5/83	May 5/83	100
83-190	May 26/83	May 24/83	100
83-218	June 16/83	June 15/83	100
83-250	July 7/83	July 4/83	100

METHODS

(1) 100 fish were randomly selected by dip net from different areas in each pond.

(2) Fish were examined internally and externally for gross signs of pathology and infectious diseases.

(3) Kidney tissue was streaked aseptically onto tryptic soy agar for the detection of bacterial pathogens.

(4) Gram stained kidney tissue was examined for the detection of bacterial and parasitic agents.

(5) As a general indicator of health, microhematocrit values were collected and blood smears made of all fish.

(6) Liver and kidney tissue of the first 25 fish in each sample was collected for histological evaluation.

RESULTS

No abnormalities or pathogens were found in any fish with the exception of 1 fish from the fourth sample (July 4/83) which was infected with Aeromonas salmonicida. The microhemocrit values were: 5 May-average 44.4%, range 32-55%; 24 May-40.5%, range 34-50%; 15 June-42.2%, range 33-50%; 4 July-43.5%, range 34-55%.

CONCLUSIONS

(1) In general, fish from all 4 health checks were in very good condition.

Externally, only 5/100 fish from the May 26 release showed cloudy corneas and 1/100 fish from the May 5 release sample had some fungal growth.

Very few fish had pale livers (3 each from May the 24 and June 15 samples).

(2) With the exception of 1 case of Aeromonas salmonicida, the causative agent of furnuculosis, no bacterial pathogens were detected. No parasites were found in the Gram stained smears of kidney tissue.

(3) Microhematocrit averages were normal and most individual readings fell within the normal range which lies between 35-40%.

(4) No significant abnormalities were found in the blood smears.

(5) All histological samples were considered normal.

SECTION 3. SEAWATER CHALLENGE TESTS

This section was provided by C. Clarke of the Pacific biological Station. The results of plasma sodium analysis from fish subjected to 24 h seawater challenge tests are summarized in Table 6. Seawater adaptability was high throughout the entire period of the releases as evidenced by the relatively low blood sodium levels. There was little effect of size on performance in seawater, possibly because the fish were rather large during the sampling period (smaller fish often show lower adaptability).

SECTION 4. RECOVERIES IN ESTUARY SAMPLING

This section was provided by the Coastal Habitat Group of tne Fisheries Research Branch (C. D. Levings). The following table lists by tag code, the numbers of chinook juveniles from the various size and time groups released in the spring of 1983 that were subsequently recovered in the Campbell River estuary and adjacent waters up until Nov. 8, 1983. Sampling is still being conducted, hence there may be additional recoveries.

Tag Code	Number recovered during period May 7-Nov 8/83
8-20-46	22
8-20-47	22
8-20-48	23
8-20-49	32
8-20-50	16
8-20-51	16
8-20-52	20
8-20-53	28
8-20-54	19
8-20-55	19
8-20-56	16
8-20-57	15
8-20-58	15
8-20-59	15
8-20-60	11
8-20-61	8
8-20-62	9
8-20-63	11
8-21-01	7
8-21-02	8
8-21-03	8
8-21-04	4
8-21-05	4
8-21-06	4
8-21-07	4
8-21-08	2
8-21-09	2
8-21-10	13
8-21-11	16
8-21-12	14
8-21-13	11
8-21-14	14
8-21-15	12
8-21-48	9
8-21-51	6
8-21-54	11
Total	466

SECTION 5. BODY COMPOSITION

This section was provided by D. Higgs and B. Dosanjhof of the West Vancouver Laboratory, Fisheries Research Branch. Analysis of body composition of samples of juvenile chinook salmon taken at release (Table 7) indicate both time and size at release had an influence on lipid, protein, and moisture content of the fish. Whole body percentages for moisture were generally inversely related to fish size whereas those for lipid and protein were directly related to fish size. In relation to time of release, percentages for body moisture and lipid decreased, while those for ash and protein increased between May 14 and July 7. Similar trends to those mentioned above have also been observed in juvenile coho salmon, especially during smoltification (Fagerlund et al. in press). However, little information is available for chinook salmon in this regard. It should be mentioned that two studies have been conducted on chinook salmon at Robertson Creek hatchery to assess the potential role of smolt body composition on marine survival (Plotnikoff et al. a and b in press).

ACKNOWLEDGMENTS

The authors would like to thank Messrs. J. Van Tyne, R. Reinhardt, and the Quinsam River hatchery staff for their help and cooperation in the carrying out of this work and C. Clark, G. Hoskins, D. Higgs and B. Dosanjh, of the Pacific Biological Station and the West Vancouver Laboratory for their participation.

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Table 1. Numbers of tagged chinook juveniles in the nine groups released at Quinsam Hatchery on May 5, 1983. Mean lengths and weights by sex, of smolts sampled at release are given.

Tag[b] Code	Number[c] Tagged Fish Released	Size Group	Length (mm)									Male and Female			
			Male			Female			Male and Female			95% Confidence Limits	Coeff. Variation	Direction Skewness[a]	Median
			$\bar{x}$	S.D.	N	$\bar{x}$	S.D.	N	$\bar{x}$	S.D.	N				
8-20-46	9,786	Small	74.66	2.82	44	75.00	2.92	48	74.84	2.86	92	74.24-75.43	3.83	-	75.00
8-20-47	9,868	Small	73.73	3.39	48	75.09	2.53	45	74.39	3.06	93	73.76-75.02	4.12	-	75.00
8-20-48	10,183	Small	73.46	3.14	39	74.84	3.64	55	74.27	3.49	94	73.56-74.99	4.70	+*	74.00
8-20-49	10,671	Medium	80.05	2.24	58	79.65	3.00	57	79.85	2.64	115	79.36-80.34	3.31	-*	80.00
8-20-50	9,819	Medium	79.57	1.93	35	79.39	1.95	38	79.48	1.93	73	79.03-79.93	2.43	+	80.00
8-20-51	9,898	Medium	79.72	1.98	43	79.61	1.59	41	79.67	1.79	84	79.28-80.06	2.25	+	80.00
8-20-52	10,244	Large	83.67	2.53	61	84.00	2.28	43	83.81	2.43	104	83.34-84.28	2.89	-	84.00
8-20-53	9,822	Large	82.85	2.46	60	82.52	2.63	31	82.74	2.51	91	82.21-83.26	3.03	+	83.00
8-20-54	9,831	Large	83.29	2.12	52	83.44	1.92	54	83.37	2.01	106	82.98-83.76	2.41	-*	84.00
Total	90,122				440			412			852				

Table 1 (cont'd)

Tag[b] Code	Number[c] Tagged Fish Released	Size Group	Weight (g)									Male and Female			
			Male			Female			Male and Female			95% Confidence Limits	Coeff. Variation	Direction Skewness[a]	Median
			$\bar{x}$	S.D.	N	$\bar{x}$	S.D.	N	$\bar{x}$	S.D.	N				
8-20-46	9,786	Small	5.03	0.58	44	5.12	0.68	48	5.08	0.63	92	4.95- 5.21	12.49	-	5.08
8-20-47	9,868	Small	4.98	0.84	48	5.17	0.46	45	5.07	0.69	93	4.93- 5.21	13.60	+*	5.07
8-20-48	10,183	Small	4.84	0.55	39	5.07	0.73	55	4.97	0.67	94	4.84- 5.11	13.46	+*	4.99
8-20-49	10,671	Medium	6.14	0.54	58	6.09	0.67	57	6.01	0.61	115	6.00- 6.23	9.93	+	6.04
8-20-50	9,819	Medium	6.08	0.58	35	6.04	0.59	38	6.06	0.58	73	5.92- 6.20	9.64	+*	5.97
8-20-51	9,898	Medium	6.06	0.45	43	6.07	0.49	41	6.06	0.47	84	5.96- 6.16	7.67	-	6.06
8-20-52	10,244	Large	7.27	0.67	61	7.30	0.60	43	7.28	0.64	104	7.16- 7.41	8.79	+*	7.25
8-20-53	9,822	Large	6.95	0.56	60	6.87	0.68	31	6.92	0.60	91	6.80- 7.04	8.65	+	6.91
8-20-54	9,831	Large	6.93	0.66	52	7.04	0.54	54	6.98	0.60	106	6.87- 7.10	8.60	-*	6.95
Total	90,122				440			412			852				

[a]Note: skewed right = +; skewed left = -; * significant at .05 level.

[b]The first number indicates agency, the second data 1, the third data 2.

[c]Estimated tag loss of 1.96% applied.

Table 2. Numbers of tagged chinook juveniles in the nine groups released at Quinsam Hatchery on May 26, 1983. Mean lengths and weights by sex, of smolts sampled at release are given.

Tag[b] Code	Number[c] Tagged Fish Released	Size Group	Length (mm)									Male and Female			
			Male			Female			Male and Female			95% Confidence Limits	Coeff. Variation	Direction Skewness[a]	Median
			$\bar{x}$	S.D.	N	$\bar{x}$	S.D.	N	$\bar{x}$	S.D.	N				
8-20-55	10,513	Small	86.61	2.79	61	86.53	3.22	78	86.56	3.03	139	86.05-87.07	3.50	-*	87.00
8-20-56	9,873	Small	85.08	3.65	37	86.10	3.30	48	85.66	3.47	85	84.91-86.41	4.05	+	86.00
8-20-57	9,951	Small	83.52	3.20	23	85.36	3.36	39	84.68	3.40	62	83.82-85.54	4.01	-	84.50
8-20-58	10,029	Medium	91.96	2.56	50	90.68	3.21	63	91.25	3.00	113	90.69-91.81	3.28	-	91.00
8-20-59	9,886	Medium	90.16	2.80	38	90.16	3.04	43	90.16	2.91	81	89.52-90.80	3.23	-*	91.00
8-20-60	9,943	Medium	90.31	3.28	36	88.95	2.89	44	89.56	3.13	80	88.87-90.26	3.49	-	90.00
8-20-61	9,840	Large	95.53	3.13	73	94.89	3.07	57	95.25	3.11	130	94.71-95.79	3.26	-*	96.00
8-20-62	9,892	Large	94.84	3.14	56	94.37	2.96	52	94.61	3.05	108	94.03-95.19	3.23	-*	94.00
8-20-63	10,171	Large	94.39	3.07	46	94.35	2.61	37	94.37	2.86	83	93.75-95.00	3.03	-	95.00
Total	90,098				420			461			881				

Table 2 (cont'd)

Tag[b] Code	Number[c] Tagged Fish Released	Size Group	Weight (g) Male $\bar{x}$	Male S.D.	Male N	Female $\bar{x}$	Female S.D.	Female N	Male and Female $\bar{x}$	Male and Female S.D.	Male and Female N	Male and Female 95% Confidence Limits	Male and Female Coeff. Variation	Male and Female Direction Skewness[a]	Male and Female Median
8-20-55	10,513	Small	8.11	0.91	61	8.04	0.93	78	8.07	0.92	139	7.92- 8.23	11.42	-	8.15
8-20-56	9,873	Small	7.70	1.02	37	7.78	0.90	48	7.75	0.95	85	7.54- 7.95	12.23	+	7.72
8-20-57	9,951	Small	7.09	0.74	23	7.65	0.71	39	7.44	0.76	62	7.25- 7.64	10.26	-	7.43
8-20-58	10,029	Medium	9.56	0.78	50	9.09	0.79	63	9.30	0.82	113	9.15- 9.45	8.77	-	9.35
8-20-59	9,886	Medium	9.02	0.73	38	9.10	0.76	43	9.06	0.74	81	8.90- 9.22	8.21	+	9.06
8-20-60	9,943	Medium	9.10	0.99	36	8.70	0.91	44	8.88	0.96	80	8.67- 9.09	10.83	+	8.94
8-20-61	9,840	Large	10.72	1.08	73	10.70	0.97	57	10.71	1.03	130	10.53-10.89	9.61	+	10.57
8-20-62	9,892	Large	10.57	0.99	56	10.24	0.86	52	10.41	0.94	108	10.23-10.59	9.06	+	10.31
8-20-63	10,171	Large	10.34	0.97	46	10.26	0.98	37	10.30	0.97	83	10.09-10.51	9.40	-	10.23
Total	90,098				420			461			881				

[a]Note: skewed right = +; skewed left = -; * significant at .05 level.

[b]The first number indicates agency, the second data 1, the third data 2.

[c]Estimated tag loss of 1.67% applied.

Table 3. Numbers of tagged chinook juveniles in the nine groups released at Quinsam Hatchery on June 16, 1983. Mean lengths and weights by sex, of smolts sampled at release are given.

Tag[b]	Number[c] Tagged Fish	Size	Length (mm)									Male and Female			
			Male			Female			Male and Female			95% Confidence	Coeff.	Direction	
Code	Released	Group	$\bar{x}$	S.D.	N	$\bar{x}$	S.D.	N	$\bar{x}$	S.D.	N	Limits	Variation	Skewness[a]	Median
8-21-1	9,929	Small	98.04	3.62	56	96.78	3.81	45	97.48	3.74	101	96.74- 98.21	3.84	-*	98.00
8-21-2	10,189	Small	97.89	3.06	57	97.27	3.85	62	97.57	3.49	119	96.94- 98.21	3.58	-	97.00
8-21-3	9,897	Small	96.47	3.64	38	96.22	3.80	55	96.32	3.72	93	95.56- 97.09	3.86	-	96.00
8-21-4	9,938	Medium	101.87	3.12	46	103.30	2.92	50	102.61	3.09	96	101.99-103.24	3.01	-	103.00
8-21-5	9,950	Medium	102.73	2.96	45	102.93	2.76	42	102.83	2.85	87	102.22-103.43	2.77	-	103.00
8-21-6	9,952	Medium	102.07	3.30	46	100.88	2.62	41	101.51	3.04	87	100.86-102.15	3.00	+	101.00
8-21-7	9,945	Large	107.04	3.46	49	107.84	3.53	38	107.39	3.50	87	106.65-108.14	3.25	+	107.00
8-21-8	9,928	Large	106.61	3.38	57	106.90	3.30	49	106.75	3.33	106	106.10-107.39	3.12	+	107.00
8-21-9	9,960	Large	106.70	3.44	54	105.28	3.55	53	106.00	3.55	107	105.32-106.68	3.35	-	106.00
Total	89,688				448			435			883				

Table 3 (cont'd)

Tag[b] Code	Number[c] Tagged Fish Released	Size Group	Weight (g) Male $\bar{x}$	Male S.D.	Male N	Female $\bar{x}$	Female S.D.	Female N	Male and Female $\bar{x}$	Male and Female S.D.	Male and Female N	Male and Female 95% Confidence Limits	Male and Female Coeff. Variation	Male and Female Direction Skewness[a]	Male and Female Median
8-21-1	9,929	Small	11.15	1.30	56	10.70	1.34	45	10.95	1.33	101	10.69-11.21	12.15	-	10.90
8-21-2	10,189	Small	10.78	1.22	57	10.95	1.64	62	10.87	1.45	119	10.61-11.13	13.36	+*	10.86
8-21-3	9,897	Small	10.54	1.44	38	10.28	1.26	55	10.44	1.33	93	10.17-10.72	12.75	+	10.28
8-21-4	9,938	Medium	12.48	1.23	46	13.07	1.12	50	12.79	1.20	96	12.54-13.03	9.40	+	12.79
8-21-5	9,950	Medium	12.86	1.14	45	12.61	1.27	42	12.74	1.21	87	12.48-13.00	9.46	+*	12.73
8-21-6	9,952	Medium	12.24	1.42	46	11.82	0.88	41	12.05	1.21	87	11.79-12.30	10.03	+	12.08
8-21-7	9,945	Large	14.55	1.77	49	14.84	1.68	38	14.68	1.72	87	14.31-15.05	11.75	+	14.35
8-21-8	9,928	Large	14.50	1.52	57	14.54	1.67	49	14.52	1.58	106	14.21-14.82	10.89	+*	14.48
8-21-9	9,960	Large	14.37	1.95	54	13.66	1.60	53	14.02	1.81	107	13.67-14.36	12.94	+*	13.84
Total	89,688				448			435			883				

[a]Note: skewed right = +; skewed left = -; * significant at .05 level.

[b]The first number indicates agency, the second data 1, the third data 2.

[c]Estimated tag loss of 1.12% applied.

Table 4. Numbers of tagged chinook juveniles in the nine groups released at Quinsam Hatchery on July 7, 1983. Mean lengths and weights by sex, of smolts sampled at release are given.

Tag[b] Code	Number[c] Tagged Fish Released	Size Group	Length (mm)									Male and Female			
			Male			Female			Male and Female			95% Confidence Limits	Coeff. Variation	Direction Skewness[a]	Median
			$\bar{x}$	S.D.	N	$\bar{x}$	S.D.	N	$\bar{x}$	S.D.	N				
8-21-10	9,856	Small	106.61	3.44	49	106.27	3.82	63	106.42	3.65	112	105.74-107.10	3.43	-	106.00
8-21-11	9,839	Small	105.19	4.74	32	105.84	3.80	44	105.57	4.21	76	104.60-106.53	3.98	-*	106.00
8-21-12	9,899	Small	105.84	4.43	38	104.72	3.74	32	105.33	4.14	70	104.34-106.32	3.93	-	105.00
8-21-13	9,883	Medium	111.30	3.26	47	111.20	2.93	56	111.24	3.07	103	110.64-111.84	2.76	-	111.00
8-21-14	9,828	Medium	111.44	3.30	54	110.76	3.56	46	111.13	3.42	100	110.45-111.81	3.08	-	111.00
8-21-15	9,887	Medium	111.68	2.66	34	110.53	3.45	30	111.14	3.09	64	110.37-111.91	2.78	-	111.00
8-21-48	10,557	Large	116.89	3.67	55	116.20	3.77	69	116.51	3.73	124	115.85-117.17	3.20	+	116.00
8-21-51	9,824	Large	116.14	3.19	64	116.62	3.71	58	116.37	3.44	122	115.75-116.99	2.96	-	116.00
8-21-54	10,033	Large	115.41	3.60	39	117.04	3.48	52	116.34	3.61	91	115.59-117.09	3.10	-	116.00
Total	89,606				412			450			862				

Table 4 (cont'd)

Tag[b] Code	Number[c] Tagged Fish Released	Size Group	Weight (g) Male $\bar{x}$	Male S.D.	Male N	Female $\bar{x}$	Female S.D.	Female N	Male and Female $\bar{x}$	Male and Female S.D.	Male and Female N	Male and Female 95% Confidence Limits	Male and Female Coeff. Variation	Male and Female Direction Skewness[a]	Male and Female Median
8-21-10	9,856	Small	14.33	1.54	49	14.00	1.83	63	14.14	1.71	112	13.82-14.46	12.11	-	14.08
8-21-11	9,839	Small	13.08	1.67	32	13.69	1.58	44	13.44	1.64	76	13.06-13.81	12.21	-	13.45
8-21-12	9,899	Small	13.78	1.85	38	13.36	1.52	32	13.59	1.71	70	13.18-14.00	12.58	+	13.54
8-21-13	9,883	Medium	16.28	1.66	47	16.18	1.55	56	16.23	1.60	103	15.92-16.54	9.85	+	16.22
8-21-14	9,828	Medium	16.19	1.67	54	15.85	1.58	46	16.04	1.63	100	15.71-16.36	10.16	-	16.20
8-21-15	9,887	Medium	16.08	1.29	34	15.82	1.42	30	15.96	1.35	64	15.62-16.29	8.45	+	16.02
8-21-48	10,557	Large	18.97	2.20	55	18.44	1.83	69	18.67	2.01	124	18.32-19.03	10.78	+	18.60
8-21-51	9,824	Large	18.66	1.92	64	18.55	1.93	58	18.60	1.92	122	18.26-18.95	10.32	-	18.58
8-21-54	10,033	Large	18.26	1.72	39	18.96	1.99	52	18.66	1.90	91	18.27-19.06	10.18	+	18.44
Total	89,606				412			450			862				

[a]Note: skewed right = +; skewed left = -; * significant at .05 level.

[b]The first number indicates agency, the second data 1, the third data 2.

[c]Estimated tag loss of 2.38% applied.

Table 5. The proportion of males in samples from each of the 36 groups of juveniles chinooks released from Quinsam Hatchery in 1983.

Release		Size Category			Average For release
		Small	Medium	Large	
1 (May 5)	Replicates	0.4783	0.5043	0.5865	
		0.5161	0.4794	0.6593	0.5157
		0.4145	0.5119	0.4906	
	Average	0.4696	0.4985	0.5788	
2 (May 26)	Replicates	0.4388	0.4425	0.5615	
		0.4355	0.4691	0.5185	0.4712
		0.3710	0.4500	0.5542	
	Average	0.4151	0.4539	0.5447	
3 (June 16)	Replicates	0.5544	0.4792	0.5632	
		0.4790	0.5172	0.5377	0.5081
		0.4086	0.5287	0.5047	
	Average	0.4807	0.5084	0.5352	
4 (July 7)	Replicates	0.4375	0.4568	0.4435	
		0.4201	0.5400	0.5246	0.4806
		0.5428	0.5313	0.4286	
	Average	0.4668	0.5094	0.4656	
	Grand Averages	0.4581	0.4925	0.5311	0.4939

Table 6. Plasma sodium levels after 24 h exposure to seawater for three size groups of chinook juveniles in each of four releases from Quinsam hatchery in 1983.

Date released	Date tested	Size group	N	Observations after challenge: Length (cm) $\bar{x}$	Length (cm) S.E.	Plasma sodium meq/L $\bar{x}$	Plasma sodium meq/L S.E.	Weight (g) $\bar{x}$	Weight (g) S.E.	Condition factor $\bar{x}$	Condition factor S.E.
May 5	May 6	Small	8	7.80	0.13	167.8	1.3	4.48	0.22	0.94	0.01
		Medium	13	8.18	0.04	167.6	1.0	5.39	0.14	0.99	0.02
		Large	14	8.59	0.06	168.7	1.1	6.43	0.13	1.02	0.02
		All	36	8.23	0.07	168.2	0.6	5.56	0.16	0.99	0.01
May 26	May 30	Small	10	9.05	0.19	166.5	1.4	7.35	0.56	0.97	0.01
		Medium	11	9.54	0.06	167.1	1.0	8.63	0.22	0.99	0.01
		Large	14	9.58	0.12	166.5	0.9	8.85	0.34	1.00	0.01
		All	36	9.43	0.08	166.6	0.6	8.38	0.23	0.99	0.01
June 16	June 6	Small	17	9.05	0.13	163.2	1.6	7.31	0.31	0.98	0.03
		Medium	8	9.58	0.12	161.7	1.5	8.64	0.35	0.98	0.01
		Large	10	9.95	0.15	160.5	1.2	9.80	0.41	0.99	0.02
		All	36	9.43	0.10	162.2	0.9	8.33	0.26	0.99	0.01
June 16	June 17	Small	11	9.83	0.09	161.6	1.1	9.59	0.30	1.01	0.01
		Medium	11	10.38	0.09	161.4	1.3	11.59	0.42	1.03	0.02
		Large	18	10.88	0.11	163.5	1.2	13.73	0.48	1.06	0.01
		All	40	10.46	0.09	162.4	0.7	12.00	0.37	1.04	0.01
July 7	July 4	Small	9	10.64	0.15	166.6	1.0	12.64	0.60	1.04	0.02
		Medium	15	10.85	0.08	166.3	1.0	13.15	0.37	1.03	0.01
		Large	9	11.57	0.13	169.0	2.1	16.10	0.52	1.04	0.01
		All	36	11.00	0.09	167.1	0.7	13.89	0.36	1.04	0.01

Notes: No mortality resulted from seawater exposure.
Size groups determined by coded wire tag reading.
Covariance analysis on seawater challenge ALL groups: no consistent correlation of length and sodium levels within groups, several pairs of group sodium means are significantly different (where the difference >3.0).

Table 7. Whole body analysis of fish from time and size at release study.

Release Sample	% moisture	% ash	% fat	% protein
May 5				
a) Small[1]	80.29	2.0	5.0	13.48
b) Medium[1]	77.13	2.0	6.21	14.96
c) Large[1]	77.73	1.93	6.25	14.59
Average	78.38	1.98	5.82	14.34
May 26				
a) Small	77.92	2.22	5.43	14.80
b) Medium	76.86	2.01	5.95	15.30
c) Large	76.20	1.99	6.41	15.39
Average	76.99	2.07	5.93	15.16
June 16				
a) Small	77.56	2.35	4.96	15.53
b) Medium	76.91	2.03	5.48	15.74
c) Large	76.30	2.09	6.07	15.84
Average	76.92	2.16	5.50	15.70
July 7				
a) Small	76.99	2.18	4.47	16.43
b) Medium	76.42	2.25	5.19	16.41
c) Large	75.85	2.15	5.77	16.16
Average	76.42	2.19	5.14	16.33

[1]Values are average of 3 samples for the May 5 release and average of 6 samples in the subsequent releases.

APPENDIX A EXAMINATION OF SEX RATIOS IN RELEASE SAMPLES.

A. ANALYSIS USING HETEROGENEITY - G TEST

As a first approach, heterogeneity G-tests (Sokal and Rohlf) were done using the numbers observed of each sex. The test was performed twice, once to test the ratios observed for each release (using the total male-female counts for each release) and once to test ratios observed for each size category (using total counts for each size).

(a) Size effect

A table summarizing results of tests of sex ratios based on size follows (the proportion of males for each category is not used directly in the calculation but is given in parentheses to aid interpretation).

Size	Male	Female	n	Proportion Male		dF	G	P
Small	522	614	1136	(.4595)		1	7.45887**	0.006
Medium	532	551	1083	(.4912)		1	0.33335ns	0.564
Large	666	593	1259	(.5290)		1	4.23510*	0.039
					Total	3	12.02732**	0.007
Sum	1720	1758	3478	(.4945)	Pooled	1	0.41519ns	0.519
					Heterogeneity	2	11.61213**	0.003

In the table, the pooled G-test is for all sizes combined as a single sample (i.e. on the summed counts shown in the table). This shows that considering the population as a whole, the sex ratio does not deviate significantly from a 50:50 ratio. Considering each size separately, the small and large category fish show significant deviations from a 50:50 ratio, but in opposite directions, small fish being predominantly female and large fish predominantly male. The ratio for medium fish is not significantly different from 50:50. These implied differences in sex ratio between sizes are confirmed by the significant heterogeneity G which is a test for uniformity of the ratios.

The total G is the sum of the individual G's for each size and its significant value indicates that considering the ratios observed for each size, the data does not conform overall to a 50:50 ratio.

To determine where the significant differences in sex ratio between sizes occurred, all possible pairwise comparisons (3) were made using the method of Sokal and Rohlf for unplanned tests of homogeneity. The only significant difference was between the small and large categories ($p<0.05$); the intermediate medium category ratio was not significantly different from either the small or the large categories.

(b) Release effect

Results of G-tests of sex ratio based on releases are summarized below:

Release	Male	Female	n	Proportion Male		dF	G	P
1	440	412	852	(.5164)		1	0.92035ns	0.34
2	420	461	881	(.4767)		1	1.90875ns	0.17
3	448	435	883	(.5074)		1	0.19140ns	0.66
4	412	450	862	(.4780)		1	1.67572ns	0.20
					Total	4	4.69622ns	0.32
Sum	1720	1758	3478	(.4945)	Pooled	1	0.41519ns	0.51
					Heterogeneity	3	4.28103ns	0.23

In this instance, there are no significant deviations from a 50:50 sex ratio. This is true for both the individual releases and for the population as a whole (pooled G; this is the same pooled G as for size tests). In addition, there are no significant differences in sex ratio between releases (non-significant heterogeneity G).

8. ANALYSIS BY ANOVA

Since the above G-tests do not take the experimental replication into account, a further analysis was done using the proportion of males in each of the 36 groups as a single observation in a 2-way (time x size) ANOVA[1]. Results are shown in the following table.

Source of Variation	Degrees of freedom	Sum of squares	Mean square	F	P
Releases	3	0.01229	0.00410	1.74 ns	0.186
Sizes	2	0.03203	0.01601	6.80**	0.005
Releases x sizes	6	0.02192	0.00365	1.55 ns	0.205
Error	24	0.05656	0.00236		
Total	35	0.12280			

[1]In this analysis, tests are for differences in sex ratios only; there is no testing against a 50:50 sex ratio.

ANOVA conclusions regarding differences in sex ratios are identical to those arrived at in the G-test analyses. The effect of size is highly significant ($p<0.01$) but there are no significant differences between releases. The ANOVA approach also tests something not analysed in the G-tests. Examination of the proportions of males in Table 5 shows that for the first three releases the proportion shows a progressive increase with increasing size. This is not true for the fourth release, however. The test of interaction (release x size) in the ANOVA is a test for uniformity of size effects between releases; its lack of significance means that although visual examination of the data suggests the size to male-proportion relationship for the fourth release differs from that of the others this could have occurred by chance alone (at the 5% significance level). In other words, it was not demonstrated that the progressive increase in the proportion of males associated with increasing size as observed in the first three releases might not have occurred in the fourth release also.

As a final step in the ANOVA the significance of the differences in sex ratios between size categories was examined. This was done using the same male proportion data grouped by size alone in a one-way ANOVA and then performing all possible pairwise comparisons using the Bonferroni test which allows for multiple comparisons (BMDP 1981). Again, results were almost identical to those obtained in the G-tests, the only significant difference in sex ratios being between small and large category fish ($P<0.05$).